LOCKHEED MARTIN

Alpha Magnetic Spectrometer
(AMS - 02)

Critical Design Review

May 12 - 16, 2003

Welding & Brazing Requirements and Certification

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AMS-02 Welding & Brazing Requirements

- Super-Fluid Helium Tank
- Integral Plumbing Tubing and Fittings
- Vacuum Case
- Trunnion Bridge Beams (for USS)
- Ring Imaging Cherenkov Counter

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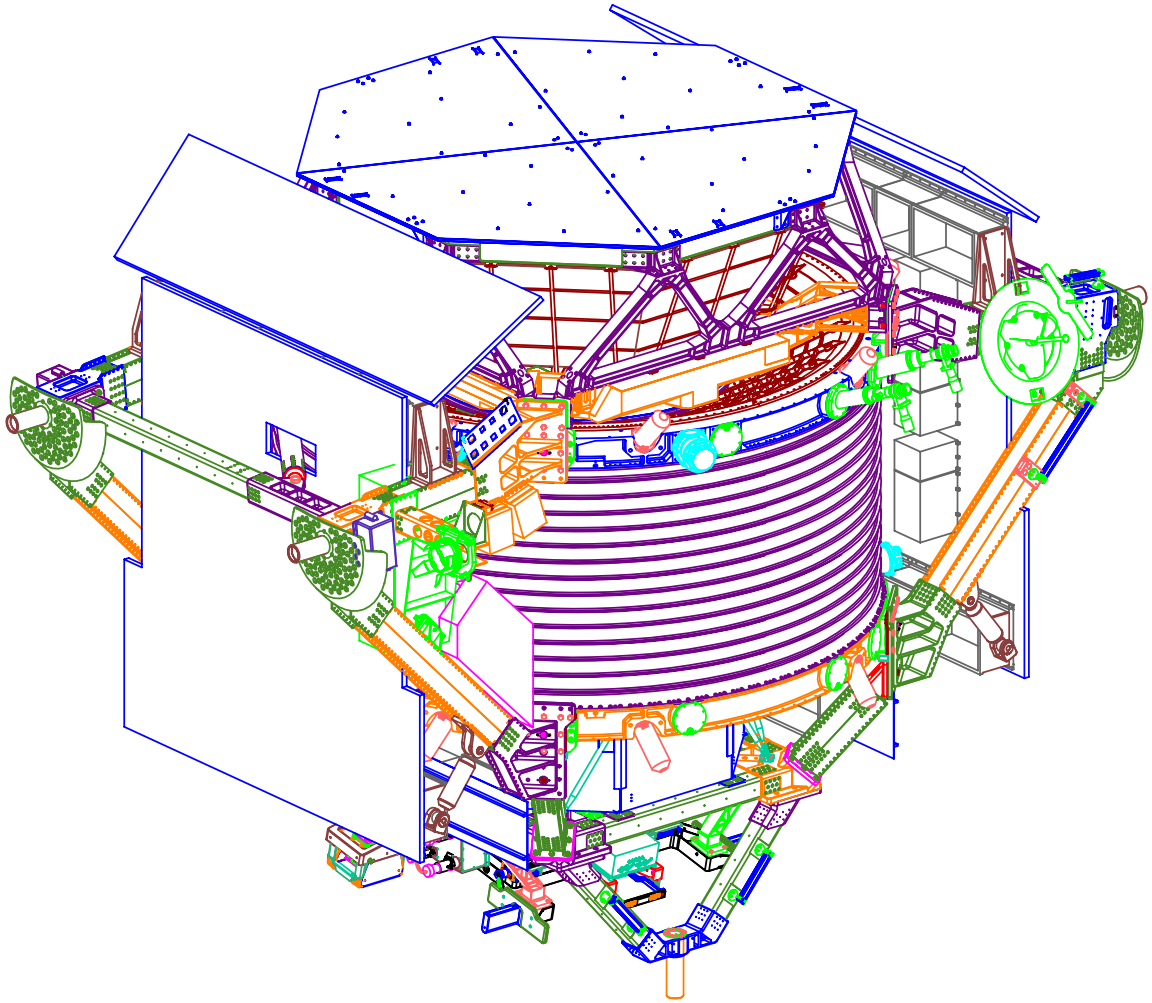

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AMS-02 Welding & Brazing Requirements

- **Welding and brazing governed by NASA, Military, or industry standards as applicable to the material being welded/brazed or process used:**
  - **NASA-STD-5006** *(Top level - Flight Hardware)*
  - **MSFC-SPEC-504** *(Fusion Welding - Aluminum)*
  - **MSFC-SPEC-560** *(Fusion Welding - Steels & CRES)*
  - **NASA/JSC PRC-0014** *(Friction Stir Welding)*
  - **MIL-STD-2219** *(Fusion Welding)*
  - **ANSI/AWS C3.x** *(Brazing Specifications)*

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AMS-02 Welding & Brazing Requirements

- **To assure mission safety, all welding and brazing procedures and personnel qualifications/certifications are required from the fabricating vendors for review by NASA/LMSO prior to commencement of welding and/or brazing operations.**

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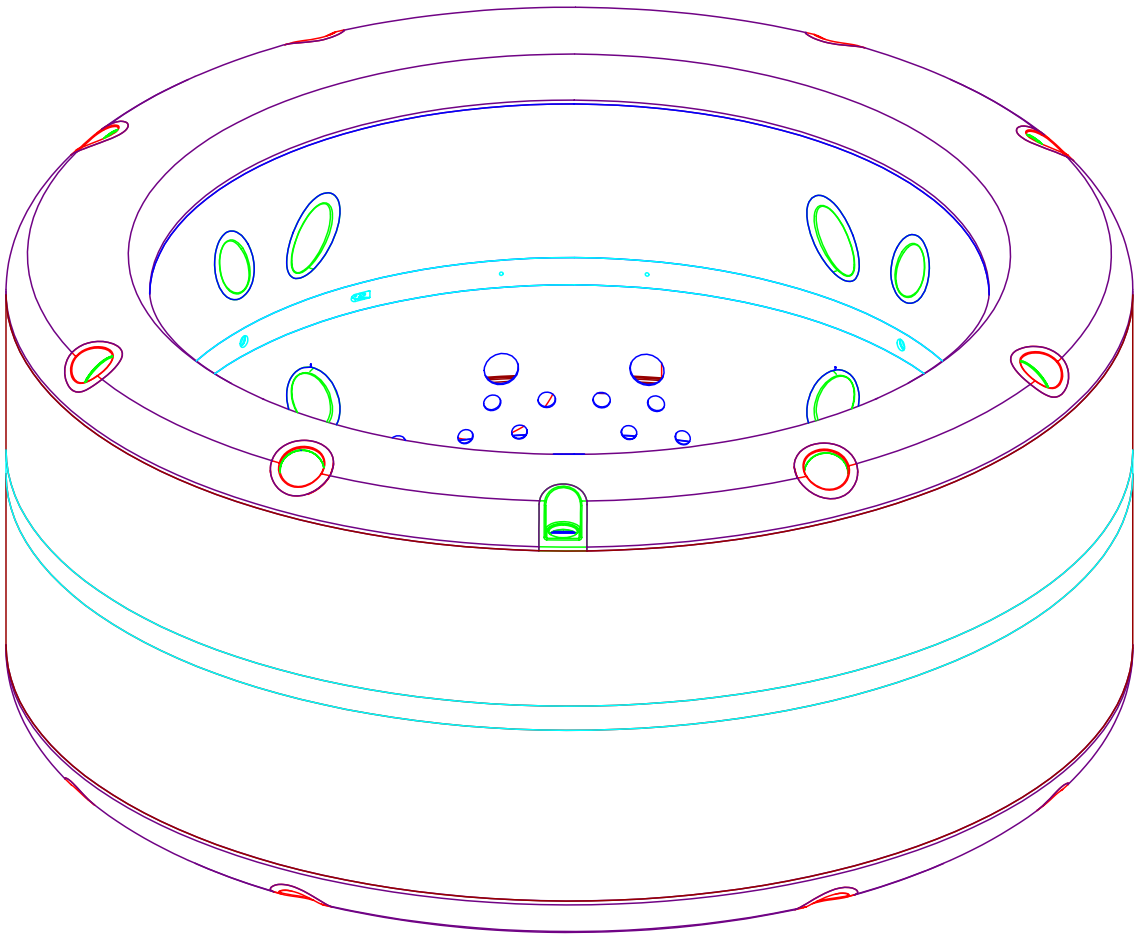
Super-Fluid Helium Tank



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Super-Fluid Helium Tank

- Space Cryomagnetics Limited, Culham, England
- 5083 aluminum alloy
- All pressure retaining welds are full penetration – no fillet welds
- Wherever possible, welds made using automated equipment – ensures best control of critical process parameters
- Weld joints utilize thickened weld seam cross sections to compensate for "knockdown" of as-welded properties of base material and to assist in fitup
- Weld joint designs do not prohibit the inspectability of the welds by standard NDE techniques (penetrant and radiographic inspection)
- Gas Tungsten Arc Welding (GTAW) is selected process
- 5183 Aluminum filler alloy is selected filler alloy

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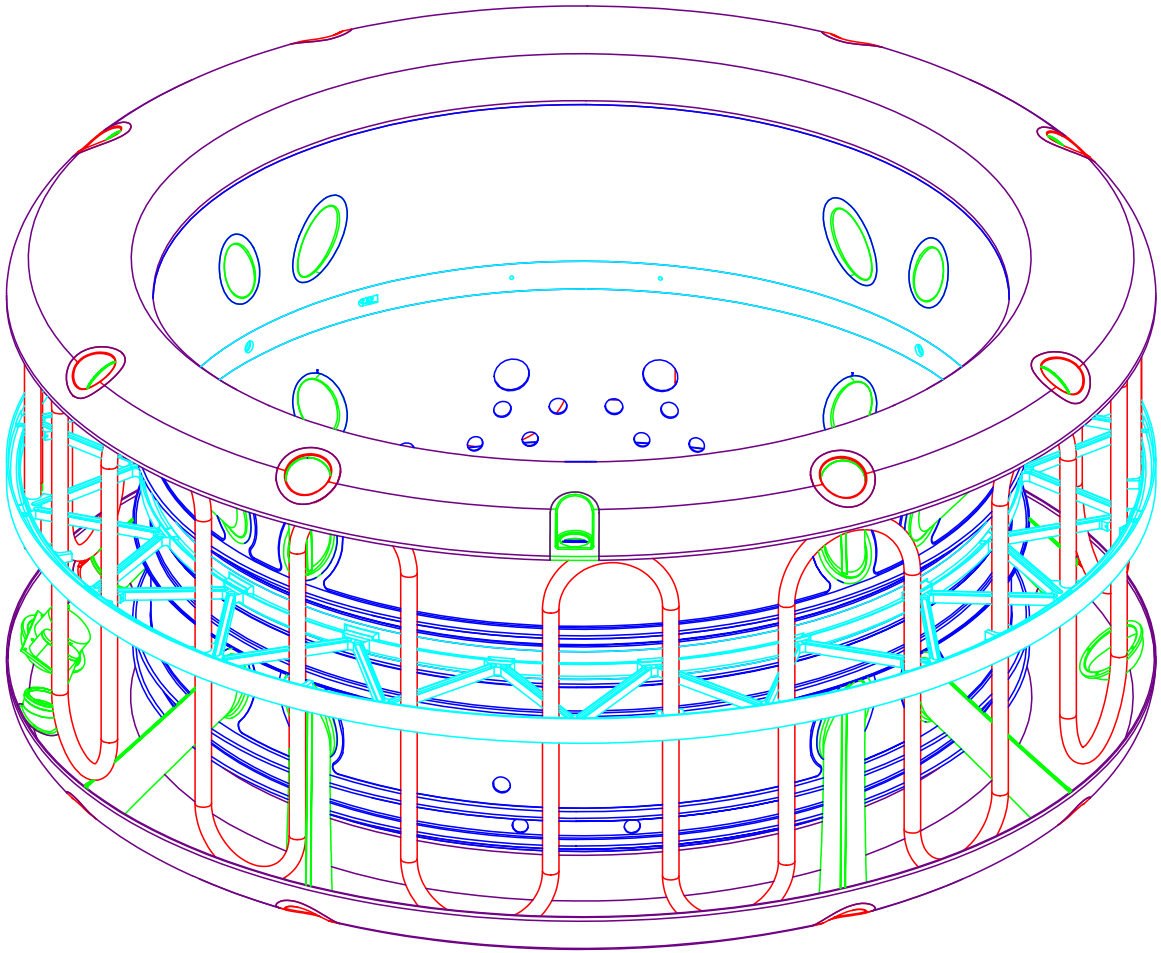
Super-Fluid Helium Tank



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Integral Plumbing Tubing & Fittings

- **TRD gas, thermal control, cryogenic fluid, and warm Helium gas systems**
- **300 series "L" grade CRES and 6xxx aluminum alloys**
- **Dissimilar alloy weld joints for TTCS and SFHe tank to plumbing transitions**
  - **Explosion welding and/or inertia welding (friction based process) is the process of choice for joining (aluminum to CRES alloys)**
- **Weld joint design gives preferential consideration to automated Orbital Tube Welding techniques (using GTAW)**
- **Weld joint designs do not prohibit the inspectability of the welds by standard NDE techniques (penetrant and radiographic inspection)**
- **Some components being considered for brazing**

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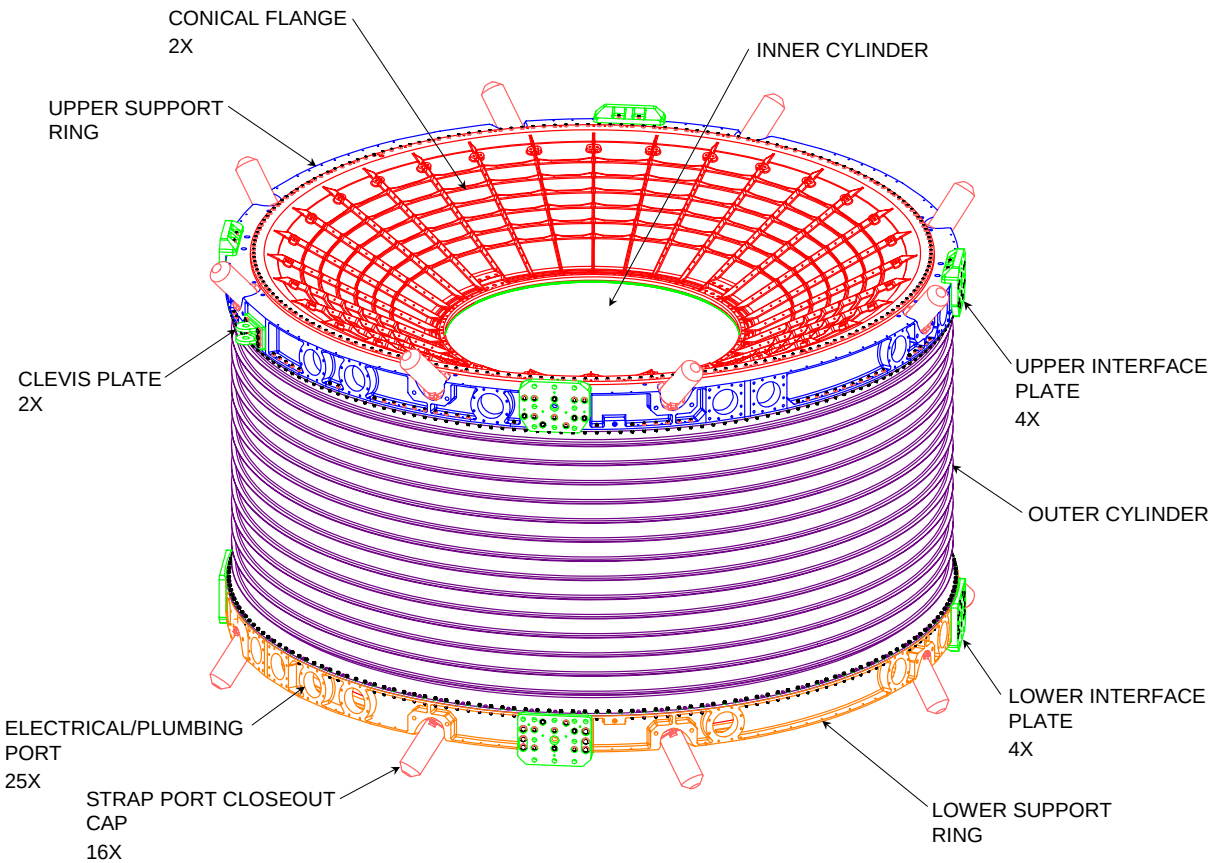
Vacuum Case (VC)



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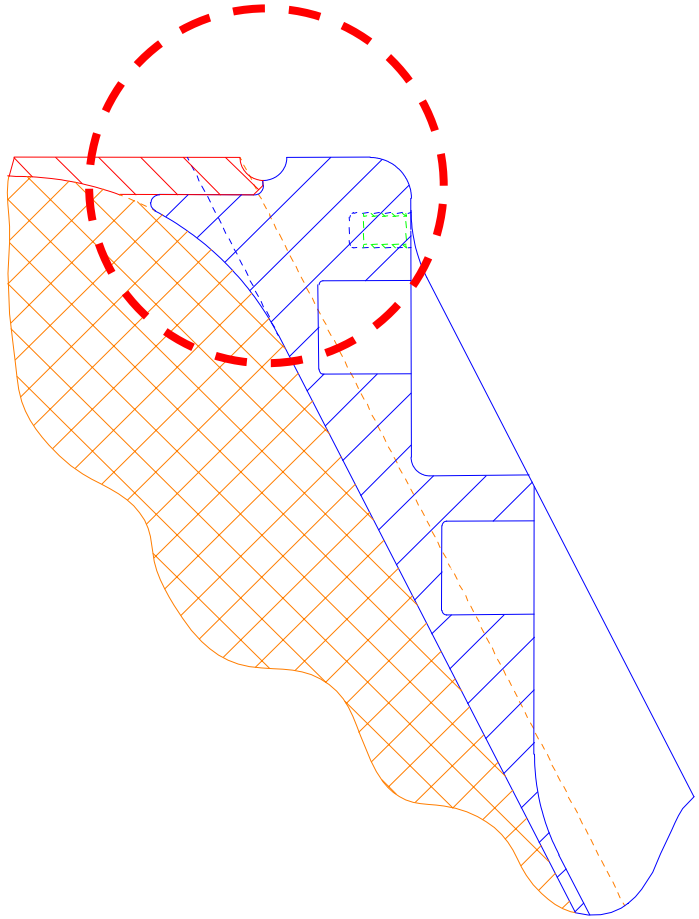
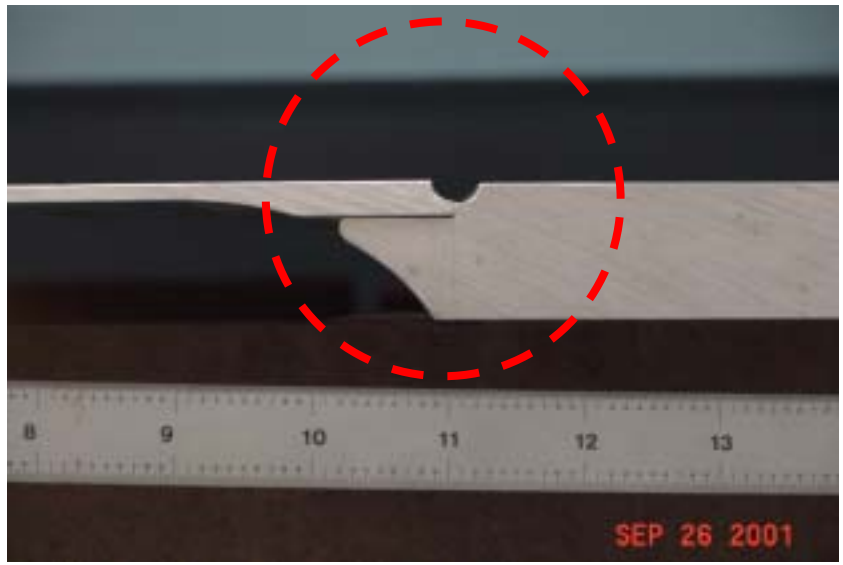
Vacuum Case (VC)

- 2219 aluminum alloy
- 2 identical circumferential welds at opposing ends of inner cylinder
- Full penetration butt joint design utilizes integral backing. This feature provides:
  - precise control of joint fitup (built in alignment mechanism),
  - ability to "contain" the internal weld bead penetration to ensure the cold mass "keep in" zone is not breached,
  - latitude for weld rework (2X) without loss of the conical flanges
- U-groove butt joint design provides excellent control over weld penetration and seam tracking
- 2 pass weld
- 2319 filler alloy
- Joint design determined to be 100% inspectable by surface and sub-surface NDE techniques. Fluorescent Penetrant Testing (PT) and specialized Ultrasonic Testing (UT) techniques developed by LMSO/NASA

Vacuum Case (VC)





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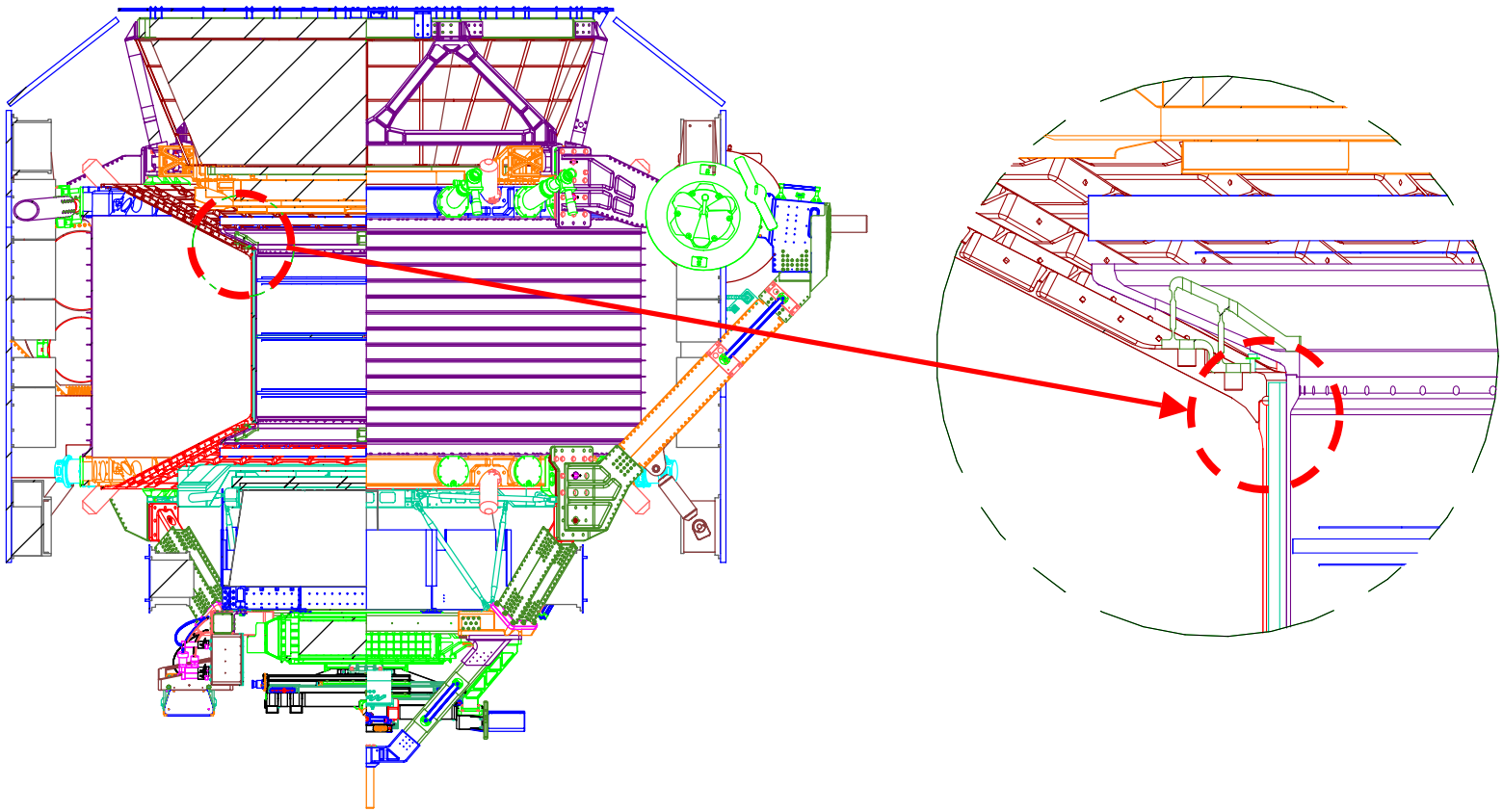
Vacuum Case (VC)



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Vacuum Case *(Cont'd)*

- **Gas Tungsten Arc Welding (GTAW)**
- **Welding shall be accomplished with automated methods**
- **Flat position welding**
- **Welding shall take place by rotating the VC and utilizing a fixed welding electrode**
- **Continuous clamp tooling at the weld joint is expected to be used to control localized weld joint distortion and mismatch**
- **Weld reinforcement removed flush to surface of inner cylinder**
- **Manual welding rework techniques have been developed to support potential welding rework/repair on-site at vendor facility. Automated weld repair techniques may also be used.**
- **Multiple weld reworks (up to 2x past the original weld) exhibit acceptable mechanical properties**

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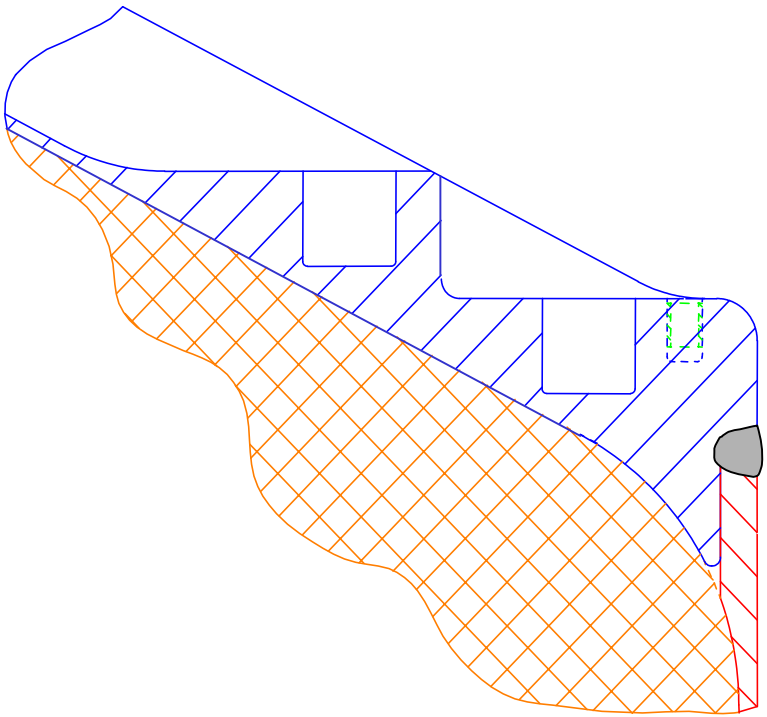
Vacuum Case *(Cont'd)*



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Vacuum Case *(Cont'd)*

- **VC welding and inspection procedures and techniques have been baselined and developed by Lockheed Martin (LM) and NASA (Structural Engineering Division - SED) in Houston.**
  - **Development effort included establishing as-welded mechanical properties (with and w/o weld reinforcement) from which a weld design allowable value was specified**
- **Transfer of this technology and all procedures will be accomplished via collaboration of LMSO and subcontractor personnel, on-site at subcontractor facility to minimize fabrication problems and ensure highest probability of success**

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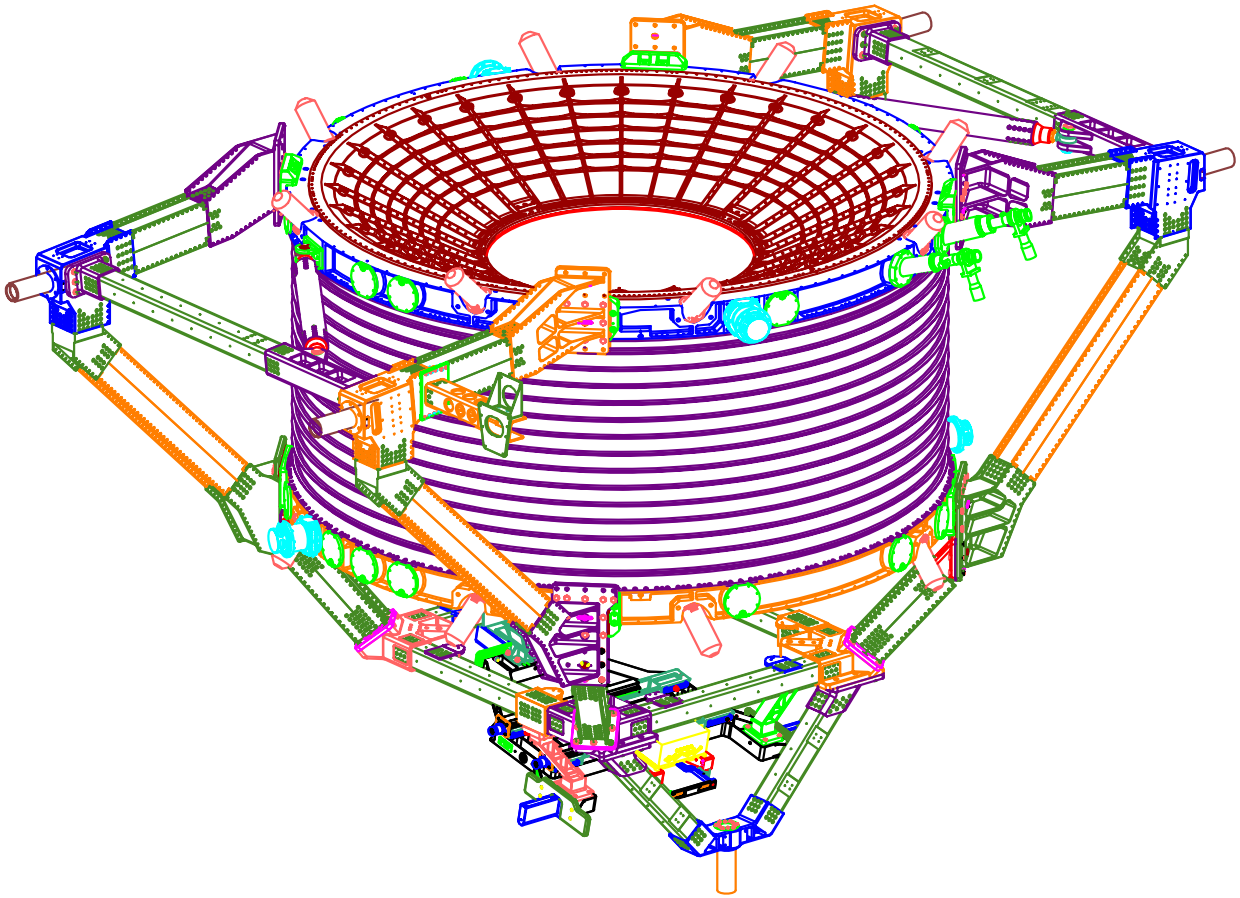
Trunnion Bridge Beams



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Trunnion Bridge Beams

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- **Integral components to Unique Support Structure (USS)**
- **Primary load bearing structure – is classified fracture critical**
- **7050 – T7451 Aluminum**
- **Each beam incorporates 2 opposing full penetration butt joints located longitudinally about the neutral axis**
- **Friction Stir Welded + full postweld heat treatment *(patent pending process)***
  - **Replaces riveted design**
  - **Solid state welding process, no filler metal required**
  - **Final postweld heat treated material exceeds MIL-HDBK-5 “A” basis properties for T7451**
  - **Heat treatment successfully minimizes stress corrosion cracking (SCC) potential**
- **Process was developed and qualified by LMSO and NASA/JSC over an 18-month period**
- **Hardware is 100% inspected using Fluorescent Penetrant (PT) and Radiographic (RT) Testing**

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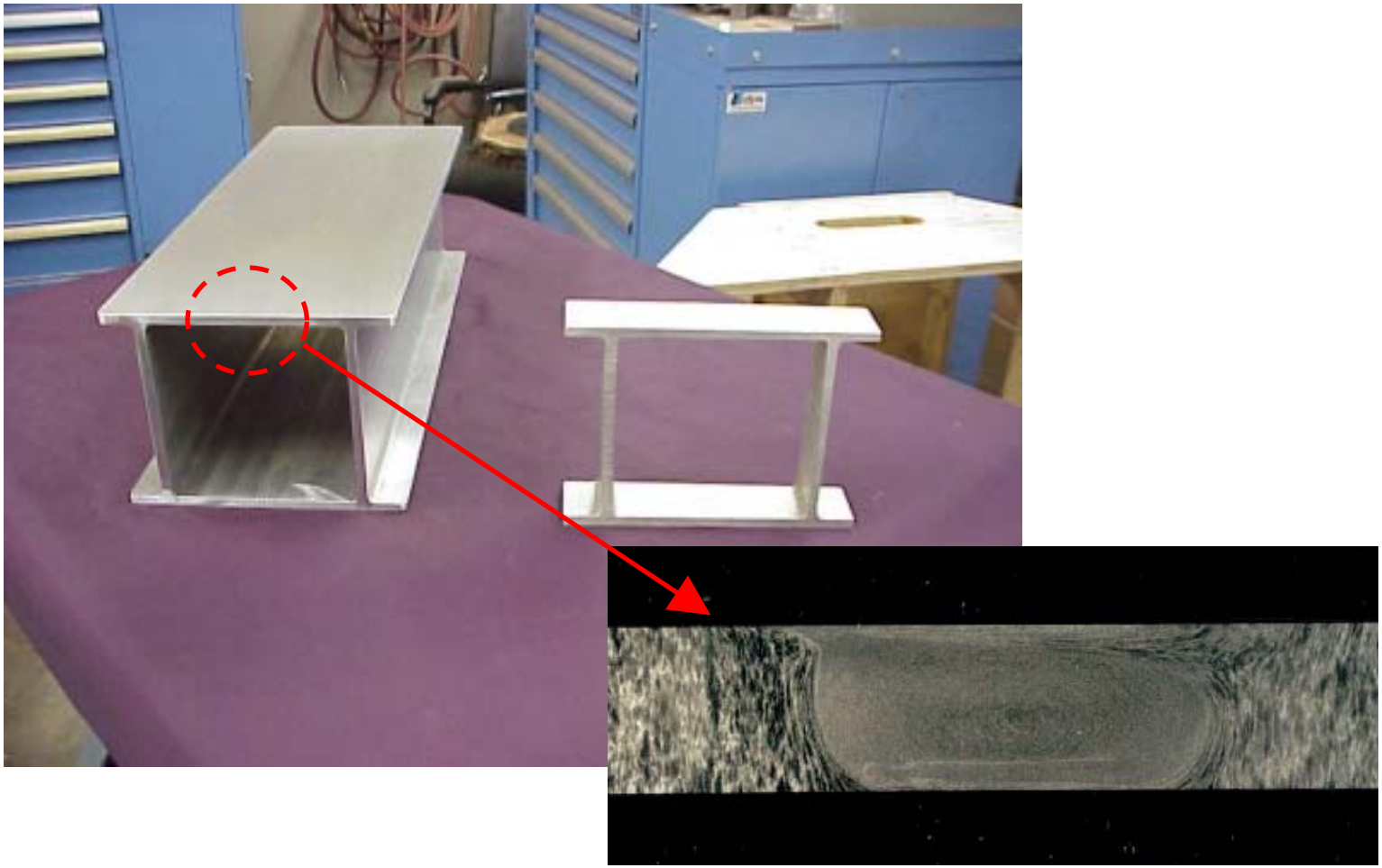
Trunnion Bridge Beams



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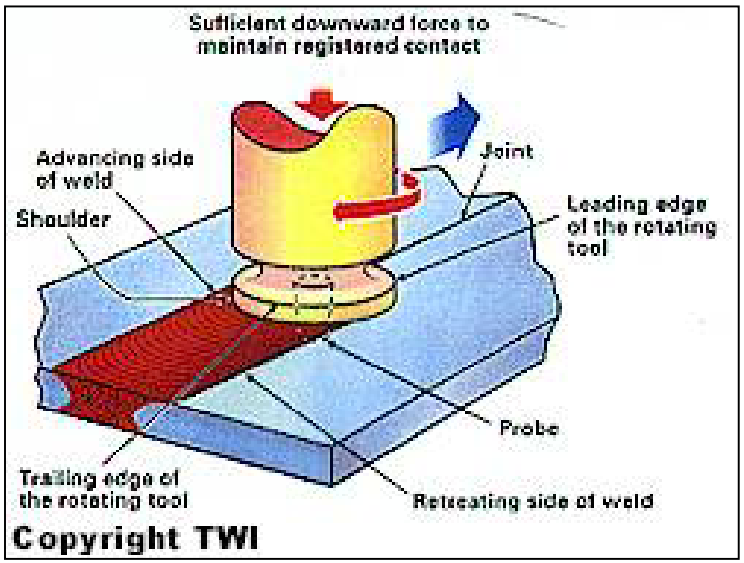
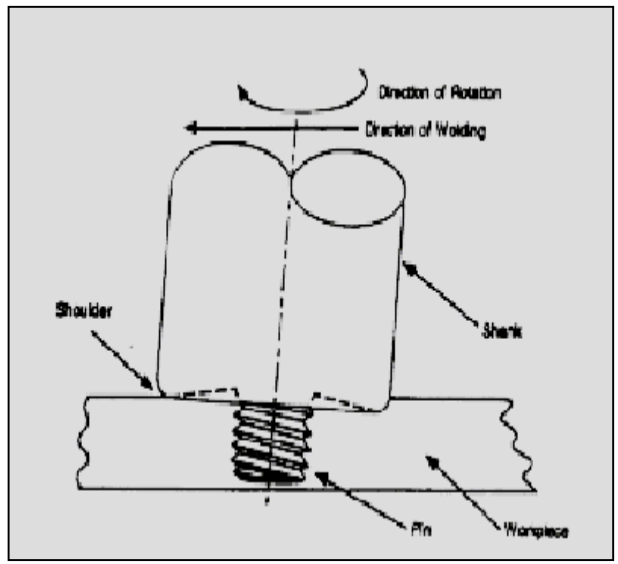
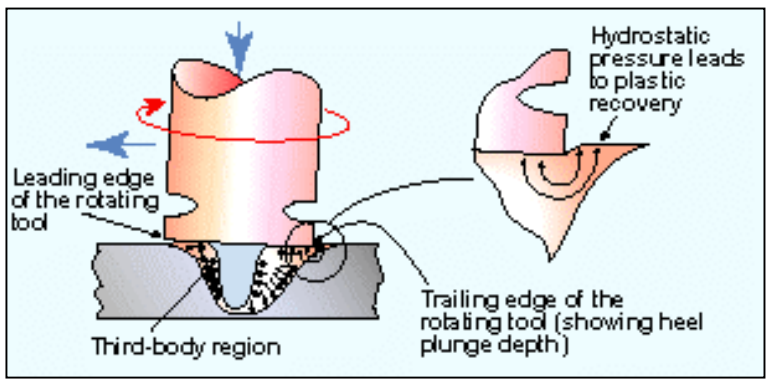
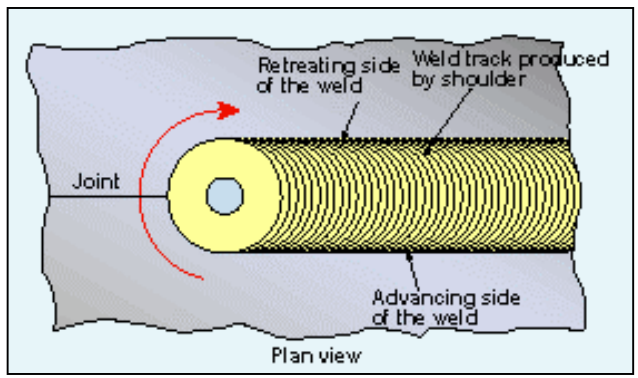
Friction Stir Welding









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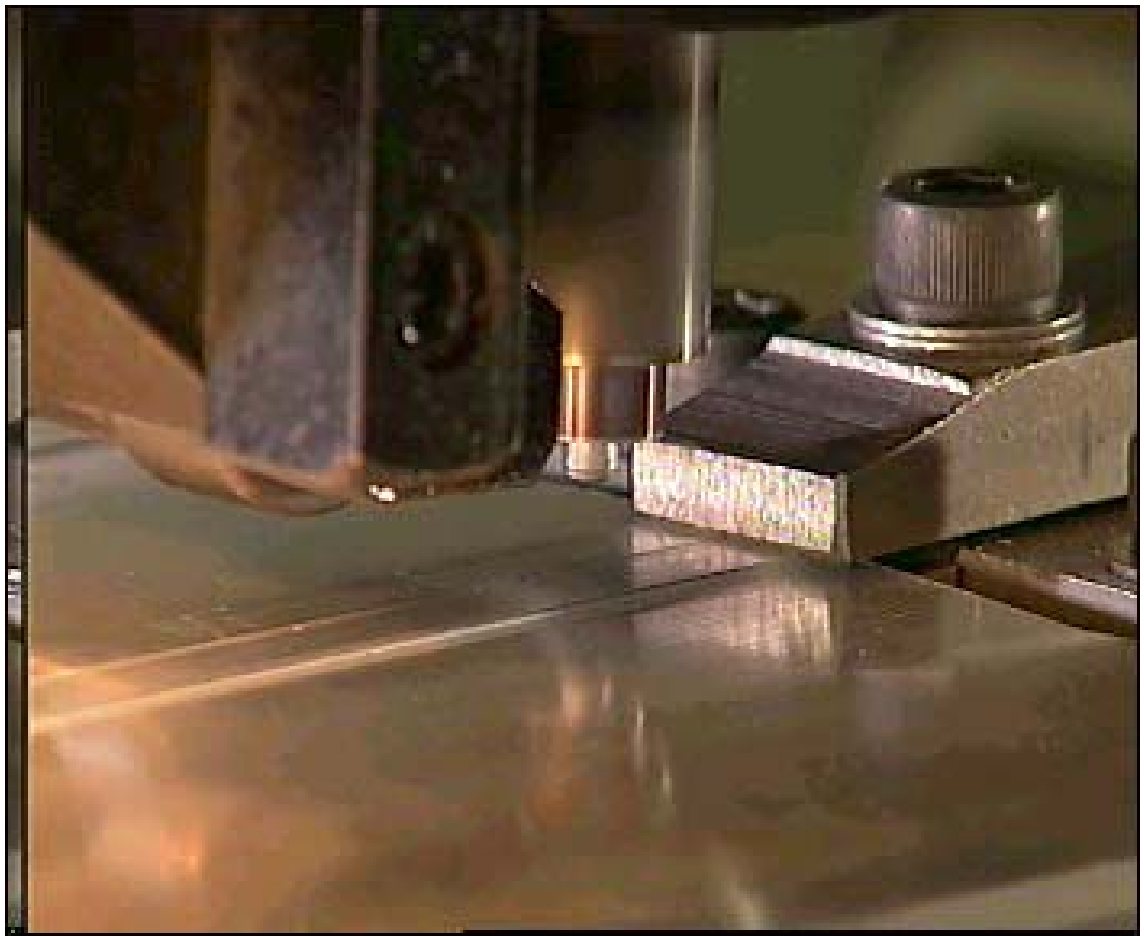
Friction Stir Welding



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Ring Imaging Cherenkov Counter (RICH)

- **Soft iron and Vacoflux Co-Fe Alloy (~50% Co and 50% Fe)**
- **Essentially non-structural welding**
- **GTA Welding (w/o filler metal) is proposed joining process**
- **MIL-STD-2219 to be the guideline for qualifying and certifying the production welding process and procedure to ensure capability**

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